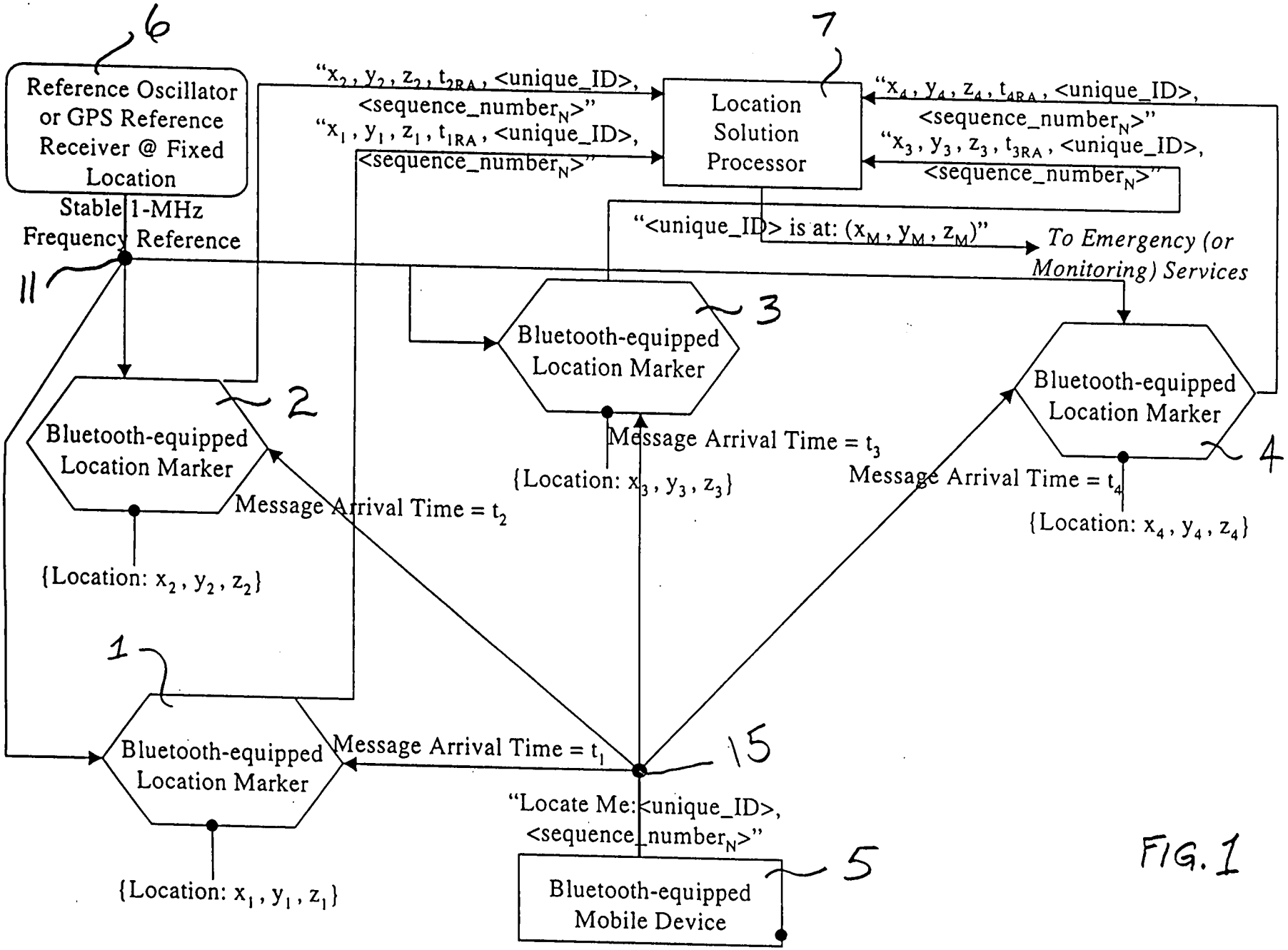
6
Reference Oscillator or GPS Reference Receiver @ Fixed Location
Stable 1-MHz Frequency Reference
11
"x_2, y_2, z_2, t_{2RA}, <unique_ID>, <sequence_number$_N$>"
"x_1, y_1, z_1, t_{1RA}, <unique_ID>, <sequence_number$_N$>"
7
Location Solution Processor
"x_4, y_4, z_4, t_{4RA}, <unique_ID>, <sequence_number$_N$>"
"x_3, y_3, z_3, t_{3RA}, <unique_ID>, <sequence_number$_N$>"
"<unique_ID> is at: (x_M, y_M, z_M)"
To Emergency (or Monitoring) Services
Bluetooth-equipped Location Marker
2
Message Arrival Time = t_2
{Location: x_2, y_2, z_2}
Bluetooth-equipped Location Marker
3
Message Arrival Time = t_3
{Location: x_3, y_3, z_3}
Bluetooth-equipped Location Marker
4
Message Arrival Time = t_4
{Location: x_4, y_4, z_4}
1
Bluetooth-equipped Location Marker
Message Arrival Time = t_1
{Location: x_1, y_1, z_1}
15
"Locate Me:<unique_ID>, <sequence_number$_N$>"
Bluetooth-equipped Mobile Device
5

FIG. 1

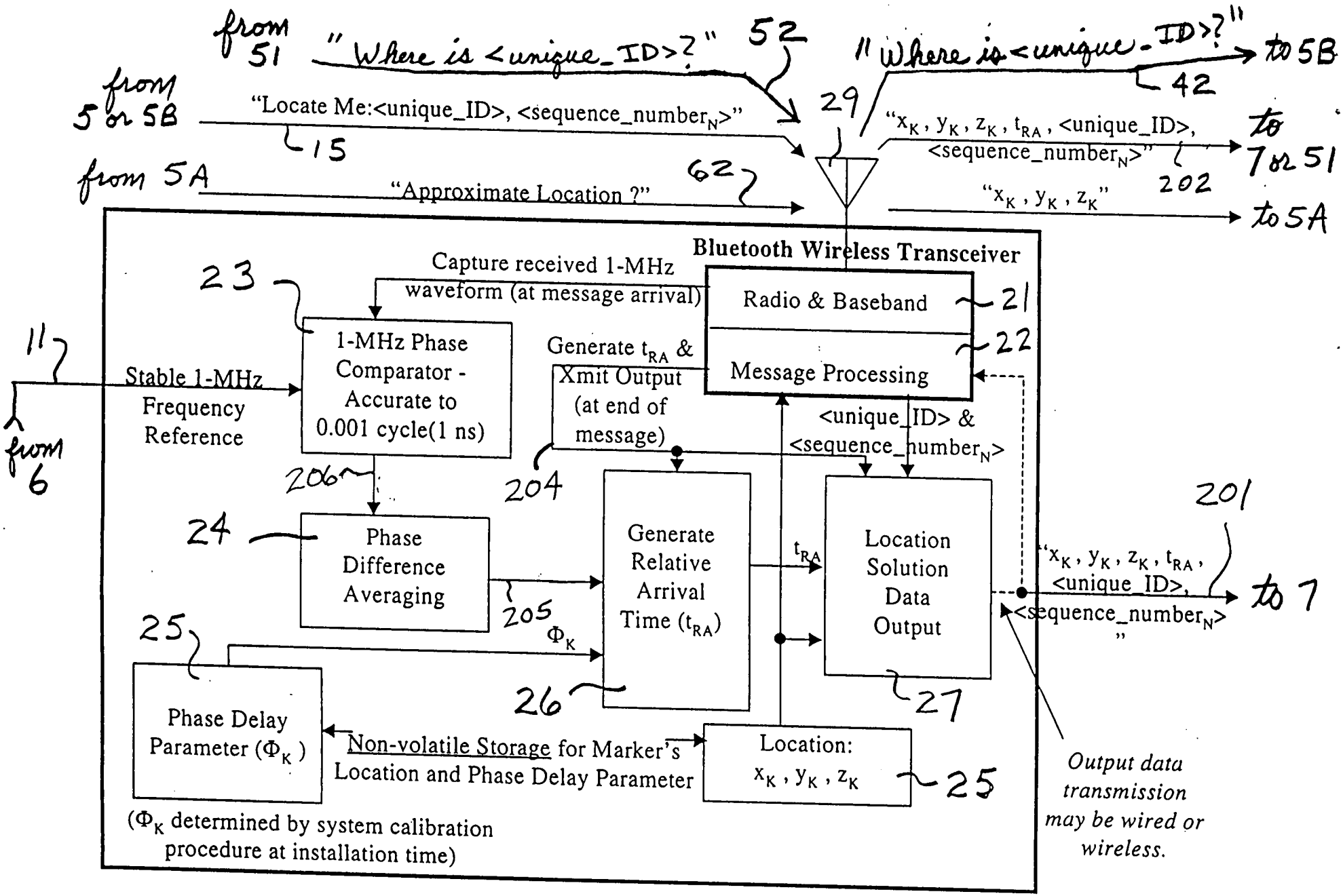
from 51
"Where is <unique_ID>?"
52
"Where is <unique_ID>?"
to 5B
42
from 5 or 5B
"Locate Me:<unique_ID>, <sequence_number_N>"
15
29
"x_K , y_K , z_K , t_RA , <unique_ID>, <sequence_number_N>"
to 7 or 51
202
from 5A
"Approximate Location ?"
62
"x_K , y_K , z_K"
to 5A
Bluetooth Wireless Transceiver
Capture received 1-MHz waveform (at message arrival)
23
Radio & Baseband
21
22
Message Processing
11
Stable 1-MHz Frequency Reference
1-MHz Phase Comparator - Accurate to 0.001 cycle(1 ns)
Generate t_RA & Xmit Output (at end of message)
<unique_ID> & <sequence_number_N>
from 6
206
204
201
24
Phase Difference Averaging
Generate Relative Arrival Time (t_RA)
t_RA
Location Solution Data Output
"x_K , y_K , z_K , t_RA , <unique_ID>, <sequence_number_N>"
to 7
205
Φ_K
25
26
27
Phase Delay Parameter (Φ_K)
Non-volatile Storage for Marker's Location and Phase Delay Parameter
Location: x_K , y_K , z_K
25
(Φ_K determined by system calibration procedure at installation time)
Output data transmission may be wired or wireless.

FIG. 2

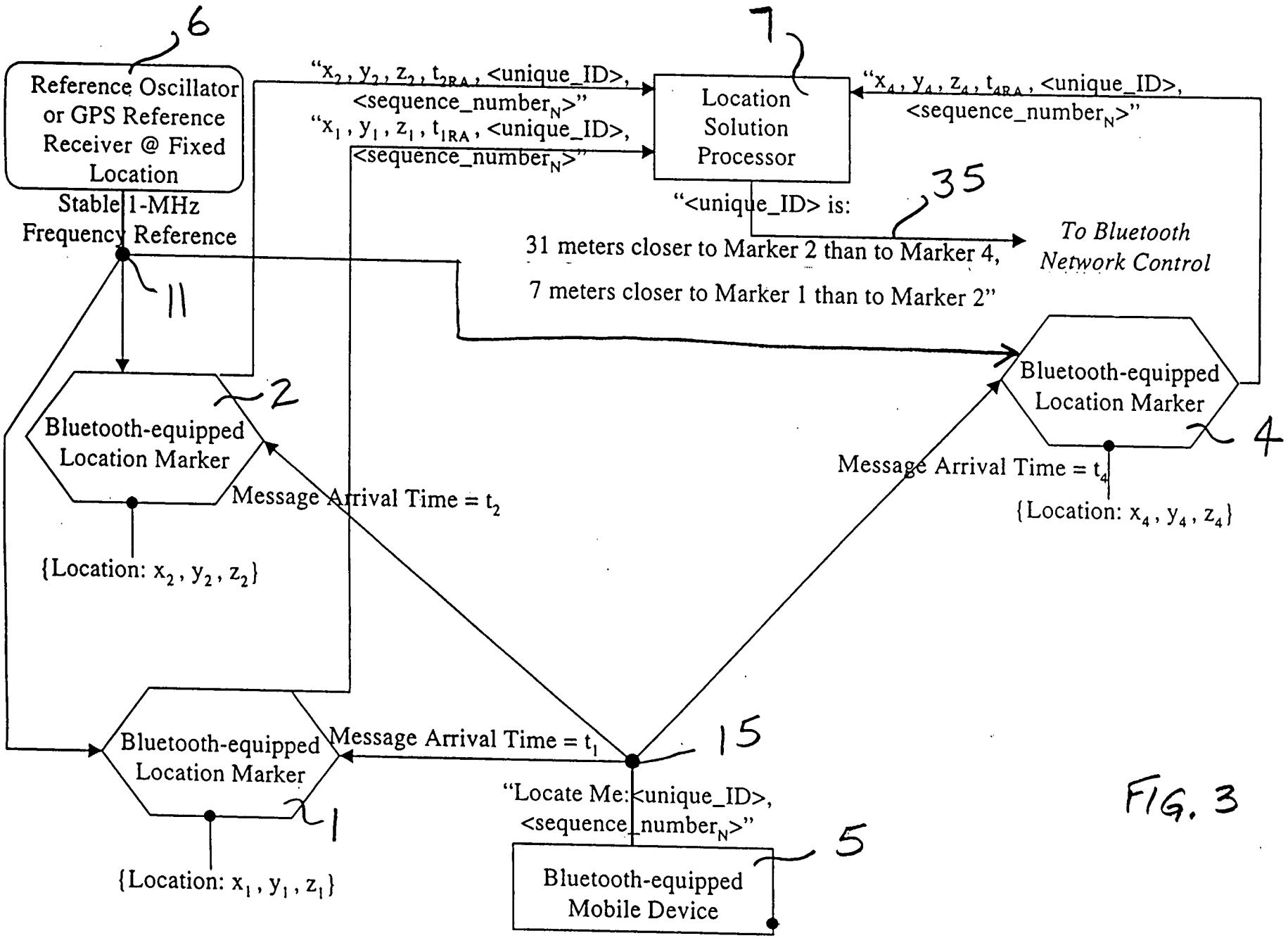
6
Reference Oscillator or GPS Reference Receiver @ Fixed Location
Stable 1-MHz Frequency Reference
11
7
Location Solution Processor
"x2 , y2 , z2 , t2RA , <unique_ID>, <sequence_numberN>"
"x1 , y1 , z1 , t1RA , <unique_ID>, <sequence_numberN>"
"x4 , y4 , z4 , t4RA , <unique_ID>, <sequence_numberN>"
"<unique_ID> is:
31 meters closer to Marker 2 than to Marker 4,
7 meters closer to Marker 1 than to Marker 2"
35
To Bluetooth Network Control
Bluetooth-equipped Location Marker
2
Message Arrival Time = t2
{Location: x2 , y2 , z2}
Bluetooth-equipped Location Marker
4
Message Arrival Time = t4
{Location: x4 , y4 , z4}
Bluetooth-equipped Location Marker
1
Message Arrival Time = t1
{Location: x1 , y1 , z1}
15
"Locate Me:<unique_ID>, <sequence_numberN>"
Bluetooth-equipped Mobile Device
5

FIG. 3

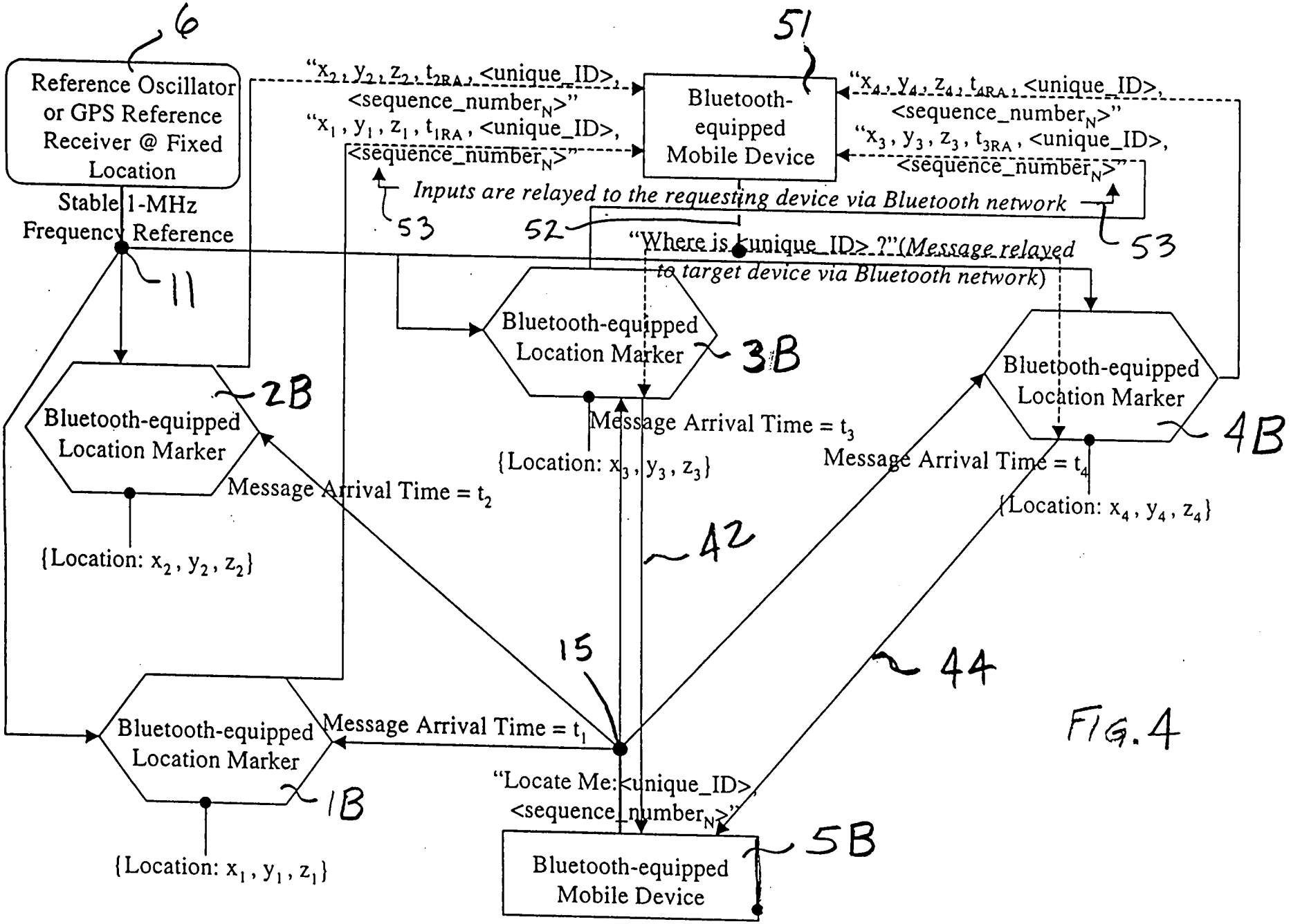
6
Reference Oscillator or GPS Reference Receiver @ Fixed Location
Stable 1-MHz Frequency Reference
11
51
Bluetooth-equipped Mobile Device
"x2, y2, z2, t2RA, <unique_ID>, <sequence_numberN>"
"x1, y1, z1, t1RA, <unique_ID>, <sequence_numberN>"
"x4, y4, z4, t4RA, <unique_ID>, <sequence_numberN>"
"x3, y3, z3, t3RA, <unique_ID>, <sequence_numberN>"
Inputs are relayed to the requesting device via Bluetooth network
53
52
"Where is <unique_ID>?" (Message relayed to target device via Bluetooth network)
Bluetooth-equipped Location Marker
2B
3B
4B
1B
Message Arrival Time = t2
Message Arrival Time = t3
Message Arrival Time = t4
Message Arrival Time = t1
{Location: x2, y2, z2}
{Location: x3, y3, z3}
{Location: x4, y4, z4}
{Location: x1, y1, z1}
42
44
15
"Locate Me: <unique_ID>, <sequence_numberN>"
5B

FIG. 4

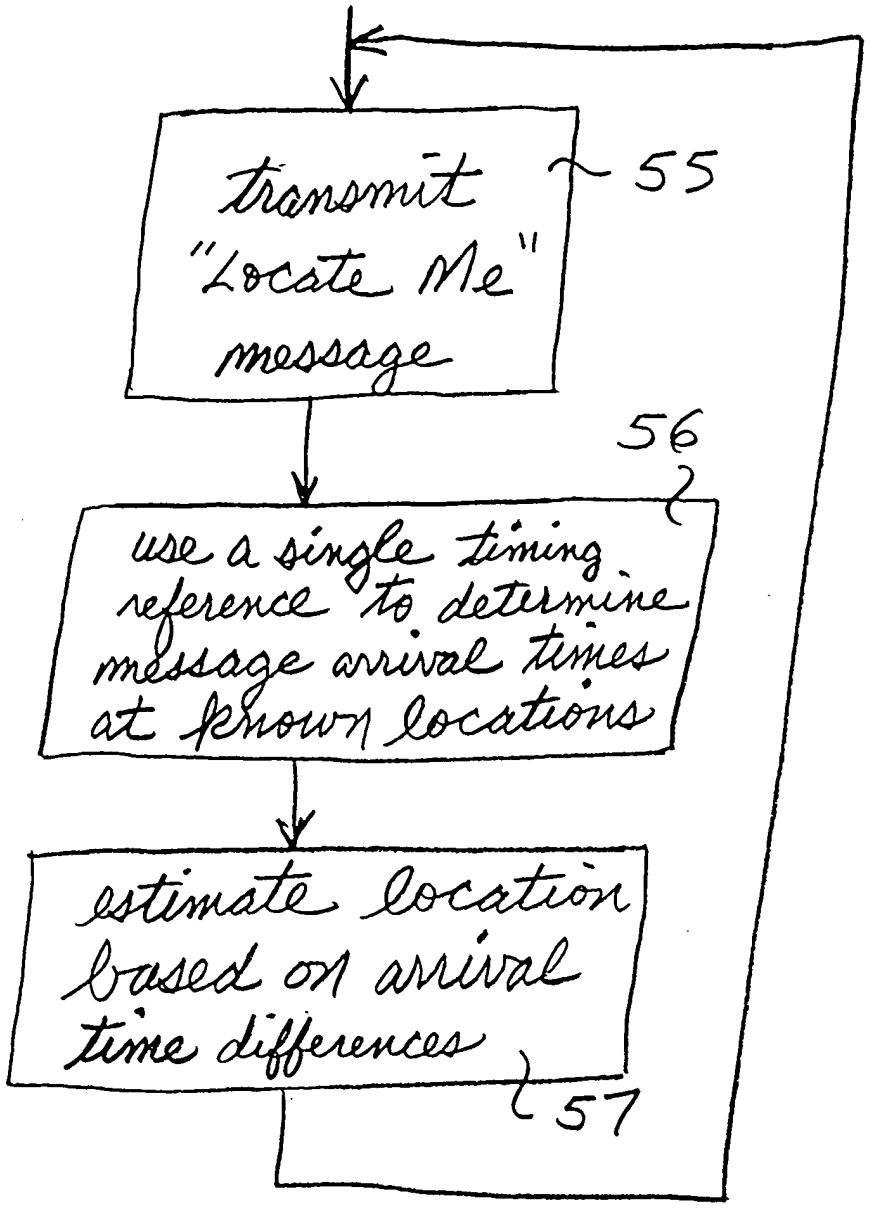
transmit "Locate Me" message
55
56
use a single timing reference to determine message arrival times at known locations
estimate location based on arrival time differences
57

FIG. 5

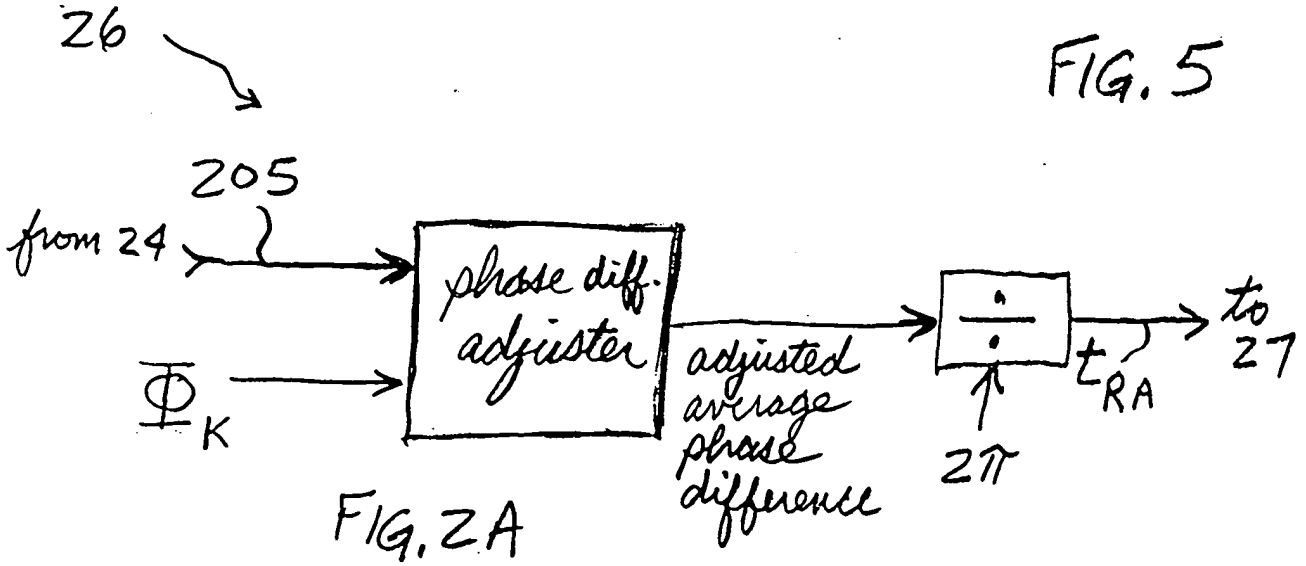
26
205
from 24
phase diff. adjuster
Φ_K
adjusted average phase difference
2π
t_{RA}
to 27

FIG. 2A

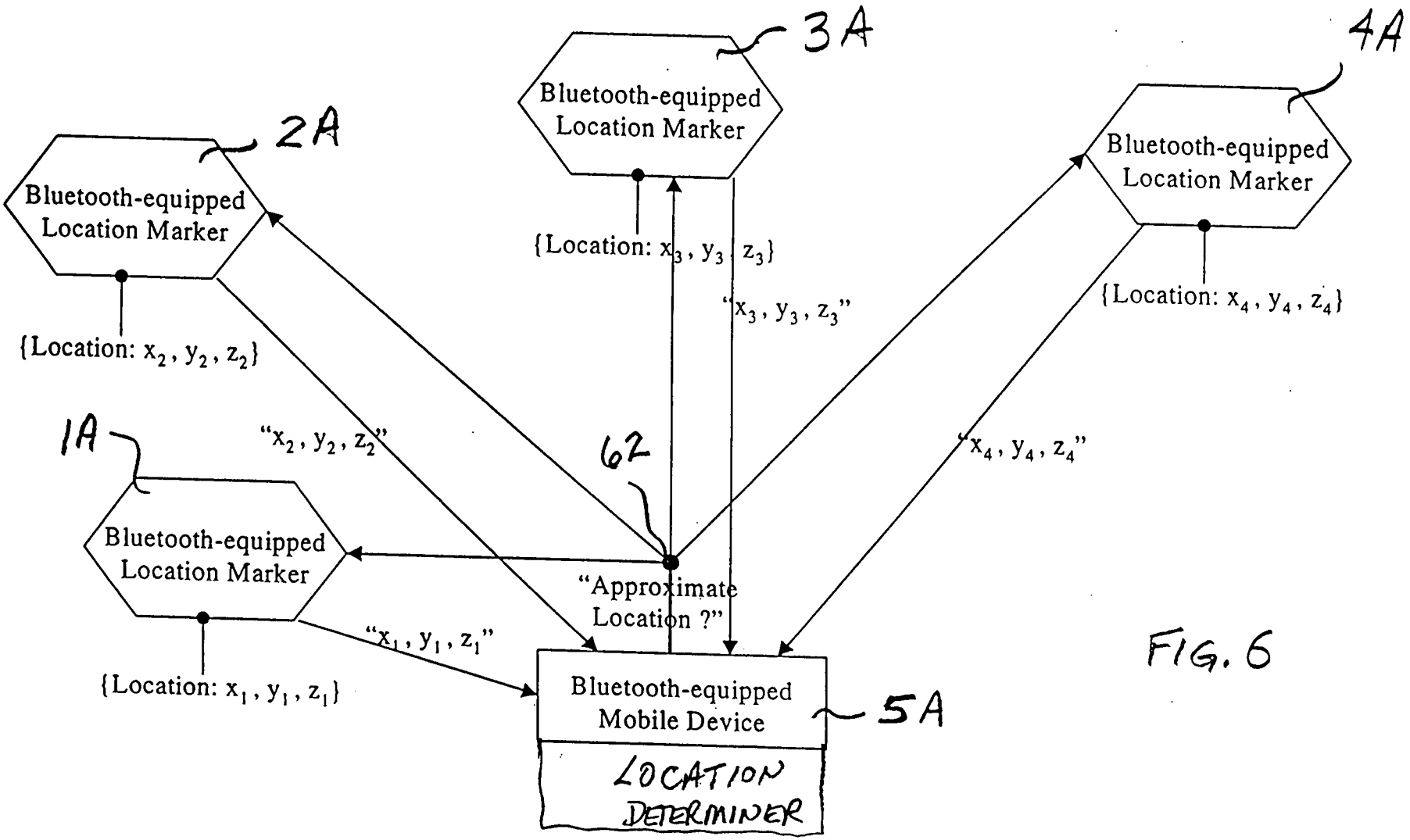
3A
4A
2A
Bluetooth-equipped Location Marker
Bluetooth-equipped Location Marker
Bluetooth-equipped Location Marker
{Location: x3, y3, z3}
{Location: x2, y2, z2}
{Location: x4, y4, z4}
"x3, y3, z3"
"x2, y2, z2"
"x4, y4, z4"
1A
62
Bluetooth-equipped Location Marker
"Approximate Location ?"
"x1, y1, z1"
{Location: x1, y1, z1}
Bluetooth-equipped Mobile Device
5A
LOCATION DETERMINER

FIG. 6

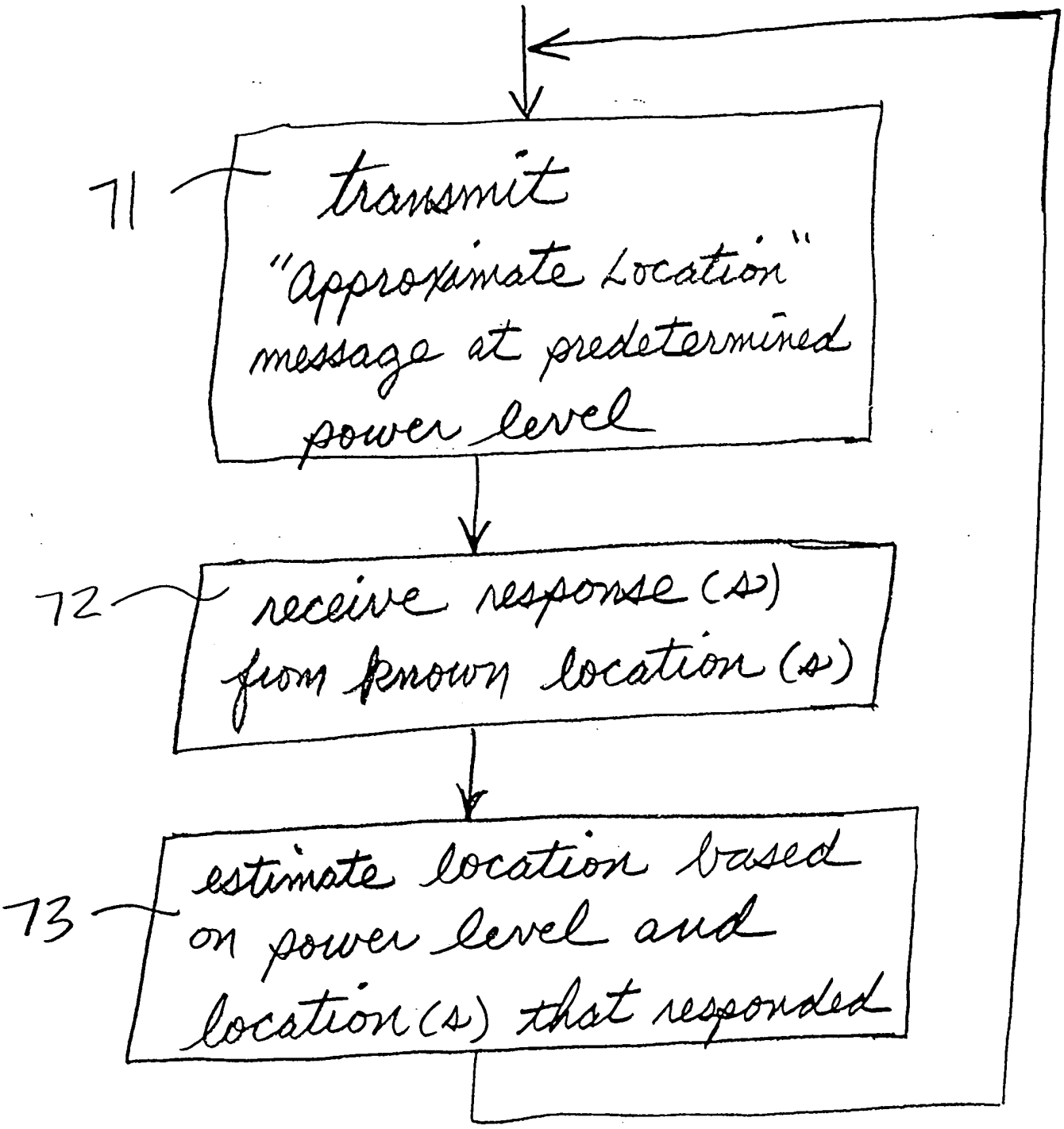
71
transmit "approximate location" message at predetermined power level
72
receive response(s) from known location(s)
73
estimate location based on power level and location(s) that responded

FIG. 7